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Effects of Computer Assisted Instruction on Secondary School Mathematics Students' Spatial Ability, Achievement and Attitude in Niger State, Nigeria

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Abstract

This study investigated the effect of computer assisted instruction on secondary school mathematics students' spatial visualization ability, achievement and attitude in Niger State. Three (3) research questions and their corresponding hypotheses guide the study. The study adopted a quasi-experimental design using pretest posttest non-equivalent, non randomized control group. The instruments for data collection were Geometry Achievement Test (GAT), Spatial Ability Test (SAT), and Mathematics and Technology Attitude Scale (MTAS) validated by six senior lecturers. The target population were all SS II mathematics students in the 150 senior Secondary Schools in three educational zones of Niger State. The sample consisted of 330 SS II (178 males and 152 females) from nine secondary schools. In each school, a stream (arm) of SS II class was randomly selected and used for the study. The three groups were pretested using GAT and SAT to determine their entry-level equivalence, while the post-test instruments are SAT and MTAS administered after six (6) weeks of instruction. The finding of the study revealed that the males outperform than females in spatial ability tasks and had higher positive attitude towards learning mathematics with technology. The study recommend mathematics teachers and instructors should adopt modern teaching pedagogies that are learner-centred and provides platform the development of spatial skills in children and adult alike.

Keywords: *Computer Assisted Instruction, Spatial Ability, Attitude, Achievement, Mathematics*

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Introduction

Mathematics is the art of manipulating figures and numbers for effective decision making that promotes scientific investigation and development (Abdullahi, 2012). Mathematics is a subject required for effective teaching and research in science and technology. Science and technology have become critical factor for socio-economic development of any nation. Learning science requires substantial application of mathematical ideas and knowledge for propelling scientific investigations and inventions (Paul, 2010 & Liman, 2013).

Mathematics is a pre-requisite subject for courses like medicine, pharmacy, nursing, architecture, fashion designing and creative art, engineering, land survey, estate management, banking, public procurement and marketing among others. The importance of studying mathematics to man and society at large cannot be over emphasized. In this regard, the study of the subject is made compulsory for all students from primary to tertiary level. Despite the benefits accruing from the study of mathematics, research findings have revealed a continuing devastating performance in the subject at all levels (Martins, 2008; Yusuf, 2010 & John, 2011). To corroborate this, the WAEC and NECO Chief Examiners reports for 2005, 2007, 2010 and 2013 have revealed a continuing decline in students' performance at senior school certificate examination (SSCE) in mathematics and geometry in particular. Some of the reasons advanced for the poor students' performance in the subject include abstract nature of some topics, teachers' instructional strategies, poor understanding of mathematics rubrics and units, non-availability of standard instructional and practical materials, poor visual skills development especially in tasks such as sketching, modeling, construction, rotation of objects, classification of shapes into 2 Dimension or 3 Dimension and measurement among others (Gana, 2009).

Attempts by educators and government at improving the quality of teaching and learning of mathematics resulted in the employment of more teachers, payment for and procurement of teaching aids and restructuring of the mathematics curriculum (Saba, 2009 & John, 2013). The use of Computer Assisted Instruction (CAI) for promoting manipulative and sketching activities especially in geometry have not received desired attention of researchers and educators. Geometry covers a substantial part of the mathematics curriculum content and accounted for between 32 to 45% of the mathematics questions in external examinations (Abdullahi, 2012 & Godwin 2014). To perform optimally in geometry, the learner must have adequate grip and understanding of spatial skills used in manipulating objects in 2 and 3 dimension. Learning geometry prepares students for higher mathematics courses and for variety of occupations requiring mathematical skills and problem solving. It is used to develop mental skills that deals understanding, manipulating, re-organizing and interpreting relationships (John, 2013).

Peterson (2013) stated that spatial ability is a cognitive factor that has been linked to higher performance in science, technology and mathematics. It is the capacity to understand and remember the spatial relations that existed among objects. Educator viewed it as unique intelligence distinguished from other forms of intelligence, such as verbal ability, reasoning ability and memory skills. Visual spatial ability is becoming increasingly important with the development and proliferation of new technologies, such as imaging, computer graphics, animation, data visualization and super computing, they are used to create complex visual images of processes that occur in the natural world (Battista, 2012 & Clement, 2013).

Spatial ability is the ability to mentally manipulate, rotate, twist or invent pictorially presented stimulus object with the aim of redefining it for better understanding. It has been found to be essential to students' success in disciplines that requires spatial thinking and application (Gana, 2012). Peter (2012) identified computer assisted instruction as an educational learning tool that provides the learners with sufficient skills and guides needed to solve spatial problems in mathematics. He defined CAI as a programmed instruction designed to boost learner's comprehension and understanding of content through the use of computer and telecommunication devices. Findings from researches have revealed that CAI is a sure means of improving spatial skills in children and adult, but Nigerian teachers rarely use it for their instruction (Kinsley, 2011 & Albert, 2012).

Attitude is another important variable in this study is that determine the willingness and psychological readiness of the learner to pay adequate attention to concept being learn. It is a social construct that revealed innate behavior towards a discipline expressing likeness or hatred.

Gender is an important variable to considered while analyzing performance in spatial visualization tasks using computer assisted instruction, while Adamu (2012) found that there was no statistically significant difference in boys and girls ability to solve problems requiring the application of spatial skills, Audu (2013) found in his study that the boys performed significantly better than girls in elementary sciences.

Several studies by Battista (2012) and Clement (2013) have shown the positive correlation between spatial ability and mathematics performance at both primary and secondary school levels. Only few researches focused on the effect of CAI on spatial visualization abilities and attitude of mathematics

students with inconsistent results. While study by Balogun (2014) revealed positive correlation between students achievement and attitude towards mathematics using CAI, Segun (2015) in his study shows negative relationship between the two variables. There is still a need to investigate the effect of CAI on students' spatial ability and attitude towards learning mathematics.

Research Objectives

1. Compare the relationship between mathematics students' achievement in spatial orientation and spatial visualization abilities using computer assisted instruction.
2. Find out the difference in spatial visualization ability of male and female SS II students taught mathematics irrespective of treatments.
3. Find out the attitude of male and female toward learning mathematics with technology.

Research Questions

1. Is there a significant relationship in mean scores between mathematics students' spatial orientation and spatial visualization abilities.
2. Will there be a significant difference in spatial visualization ability between male and female students taught mathematics irrespective of treatments.
3. Is there a significant difference in the attitude towards mathematics of male and female SS II using computer assisted instruction.

Research Hypotheses

1. There is no significant relationship in the mean achievement scores between mathematics students spatial orientation and spatial visualization abilities.
2. There is no statistically significant difference between males and females in their spatial visualization ability mean scores as measured by the spatial ability test irrespective of treatments.
3. There is no significance difference in the attitude of male and female SS II taught mathematics using Computer Assisted Instruction.

Methodology

The research design adopted for this study is a quasi-experimental. It is a pretest posttest, non-equivalent, non-randomized control group. It was a modified version of the non-equivalent control design frequently used in educational research when the researcher cannot randomly assign students to the experimental or control group but must work with intact classes (Campbell & Wallen, 2003). The use of this modification minimized some of the possible threat to internal validity caused by the selection process while imposing some controls on the sensitization effect of the pretest (Yusuf, 2009).

The design consisted of three levels of independent variable (two treatments and a control group), two level of gender (male and female) and the dependent variables are the posttest scores (SAT and MTAS), while the pretest scores serves as covariate. The target population for the study was the entire senior secondary mathematics students (SS II) in all the one hundred and fifty (150) schools within the three educational zones of Niger State. The estimated total number of SS II students were 16,527 at of 2015 (Niger State Ministry of Education, Minna). The choice of SS II classes for the study was based on the fact that dynamic and transformation geometry consisted 40% of the mathematical content expected to learn at that level and the level is stated non-examinable that is only promotion examination is written at this level.

The sample for the study was drawn from nine (9) co-educational secondary schools in Niger State. A purposive sampling was used to select three (3) schools from each zone and assigned to experimental I, II and control groups. The schools purposively sampled were based on the availability of basic teaching materials, manpower and computer laboratory. Inorder to avoid interaction effect of the subjects before and after treatments, separate schools were used for the study. In each school, a stream (arm) was randomly selected and used for the study. The sample size was three hundred and thirty (330) consisting of 178 males and 152 females from nine intact classes. The Exp I has 117 students, Exp II has 104 students and the control group had 109 students.

The instructional method employed for the study was computer assisted instruction for individualization and team-learning. The instrument for data collections were Geometry Achievement Test (GAT), Spatial Ability Test (SAT) and Mathematics and Technology Attitude Scale (MTAS).

The instrument was subjected to face and content validation by six senior lecturers from both the Federal University of Technology, Minna and Ibrahim Badamasi Babangida University, Lapai. The advice and comment of the validations help in the final selection of the items of the instruments. A pilot

study and field trial validation was also conducted to determine the effectiveness, appropriateness of the CAI and items of the instruments. The result of pilot study was used to compute the reliability coefficients of the instrument.

GAT consists of twenty – five multiple choices items, SAT consisted of twenty multiple-choice and MTAS consisted of twenty items questionnaire. All the groups were pretested using GAT and SAT. The pretest was done to determine of the entry-level equivalence of the three groups. The Experimental Group I and II had their lessons in the laboratory using a carefully prepared lesson plan by the researchers, while the control group had their in the classroom using traditional lecture method. The three (3) groups were then post-tested after six (6) weeks of instruction using SAT and MTAS. Nine mathematics teachers were used as instructors and research assistants for the study. The research assistants were trained and adequate briefed on the objective of the study. The data collected were analyzed using the mean, standard deviation and analysis of variance. Post hoc analysis was performed where significant difference existed.

Results

The results from the administration of posttest (MTAS and SAT) were presented in tables based on the research questions and their corresponding hypotheses.

Research question 1: Is there significant relationship in the mean achievement scores between mathematics students' spatial orientation and spatial visualization abilities?

Table 1. Mean and standard deviation of mathematics student in spatial orientation and spatial visualization

Tasks	N	Mean (x)	SD
Spatial Orientation	330	58.24	15.147
Spatial Visualization	330	56.42	12.919

Table 1 revealed the mean and standard deviation values of mathematics students in spatial orientation and spatial visualization to be 58.24 and 56.42 respectively. Similarly, the standard deviation values of 15.147 and 12.919 for SOAT and SVAT respectively was significantly different. This means that mathematics students performed better in tasks requiring spatial orientation skills than in tasks requiring spatial visualization skills.

Research question 2: Will there be a significant difference in spatial visualization ability of male and female students taught mathematics in respective of treatment.

Table 2. Mean and standard deviation of male and female in the post-test (SAT)

Gender	N	Mean (x)	SD
Male	178	59.69	14.064
Female	152	56.68	16.194

Table 2 revealed the mean and standard deviation values in respective of the male and female students in the post-test. The mean values of 59.69 and 56.68 for male and female respectively are significantly different. Similarly, the standard deviation values of 14.064 and 16.194 are significantly different for the male and female mathematics students. This means that the male outperformed than female in the posttest.

Research Question 3: Is there a significant difference in the attitude towards learning mathematics of male and female SS II Students in Niger State?

Table 3. Mean and standard deviation of male and female students' attitude towards learning mathematics

Variable	N	Mean (x)	SD
Male	178	2.97	1.467
Female	152	2.65	0.958

Table 3 above shows the mean and standard deviation of students' responses to attitude questionnaire. The mean values of 2.97 and 2.65 for male and female are significantly different. Also,

the S.D values of 1.467 and 0.958 for the male and female differ significantly. This means that the male has higher positive attitude towards learning mathematics with technology than their female counterparts.

HO₁: There is no significant relationship in the mean achievement scores in spatial orientation and spatial visualization abilities of mathematics students using CAI.

Table 4. Pearson moment correlation of students' spatial orientation and spatial visualization abilities.

Tasks	N	Mean (x)	—	Correlation	P-value
SOAT	330	58.24		*273	0.01
SVAT	330	56.42			

Table 4 revealed the Pearson Moment Correlation analysis of mathematics students performance in spatial orientation and spatial visualization tasks. The mean values of 58.24 and 56.42 are significantly different. The correlation value of 0.273 at P-value of 0.01 is also significant. This means that the null hypothesis one which state that there is no significant relationship in the mean achievement scores of student in SOAT and SVAT is rejected. This finding is in agreement with Adebayo (2014) result, which revealed that Mathematics student performed better in tasks involving paper folding, surface development and construction activities. The enhanced performance in spatial orientation might be due the practical nature of tasks involved and the use of varied illustrations during manipulation.

HO₂: There is no statistically significant difference between male and female in their spatial visualization mean score as measured by SAT irrespective of treatments.

Table 5. Pearson Moment Correlation analysis of means of males and females in the post-test

Gender	N	Mean (x)	—	Correlation	P-value
Male	178	58.34		*157	0.02
Female	152	56.60		**115	

Table 5 shows the correlation analysis of male and female mathematics as the post-test. The mean values of 58.34 and 56.24 for male female students respectively is significant is in favour of the male gender. The correlation values of 0.157 at 0.02 is significant, hence the null hypothesis two is not accepted. The better performance in spatial ability tasks in favour of the male is supported by the findings of Abdullahi (2012) and Gana (2015) on reasons why males dominated science engineering and technology related professions. Several literature have revealed high positive correlation between performance in spatial visualization and mathematics achievement.

HO₃: There is no significance difference in the attitude of male and female students towards learning mathematics with technology.

Table 6. Analysis of variance of Male and Female students' attitude towards learning mathematics using technology

	Sum of Squares	DF	Mean square	F	Sign
Between Group	7.852	1	7.852	6.002	.001
Within Group	183.352	338	0.559		
Total	191.204	329			

Table 6 revealed analysis of variance in respect of male and female attitude towards learning mathematics with technology. The mean square value of 7.852 and 0.559 for between and within groups are significant. Similarly, the F-value of 6.002 at 0.05 alpha level is also significant. Hence, the null hypothesis three (3) on the attitude of male and female towards learning mathematics is not accepted. This result is in agreement with the finding of Joseph (2014) on the attitude of male and female towards physics using computer assisted instruction. His finding revealed positive attitude towards learning physics by males than females.

Discussion

The positive effects of teaching and learning on spatial visualization ability found in this study are consistent with those from previous studies where similar teaching interactions had been used (Sorty 2003 & Ben-Chaim 2012). The presence of gender related differences in this study which shows superior performance in favour of the males was supported by the empirical evidences from the studies Conducted by John (2013) and Yusuf (2015) on spatial visualization ability of computer science students. One possible explanation is that the types of spatial tasks employed in the present study might be considered difficult by the female gender. For example, surface development, cube comparison and mental rotation tasks are spatial activities considered stressful by females. The spatial visualization ability instrument, which consisted of types of spatial tasks may have provided the male subjects with the opportunity to demonstrate the full spectrum of their spatial visualization skills than the females.

The enhanced performance in spatial orientation at the expense of the spatial visualization might be due to the frequent encounter of subject with objects ground their environment and their frequency of manipulation. Thus, paper folding and surface development are common task the subjects are used to since earlier years. The better performance in spatial orientation tasks by subjects is in agreement with Gabriel (2012) findings on why students paid difficulty identify symmetric and asymmetric properties.

In the same vain, the low attitude level towards learning mathematics with technology exhibited by females might be due to inadequate hands-on experience and training compared to their male counterparts. The training gap outside the classroom experience might have been responsible for the slight difference in attitude as explained by Joseph (2014). Thus students who had background knowledge had more positive attitudes than students who had no background in the dimensions of scientific manner.

Conclusion

This study investigated the effect of computer assisted instruction on spatial visualization ability and attitude towards learning mathematics with technology. The finding from the study revealed gender difference in favour of the male in performance and attitude towards mathematics. Further research can be conducted in order to determine the contribution of mathematical knowledge related to set operations and the spatial abilities of students emphasizing different age levels.

Recommendations

Based on the finding of the study, it is recommended that:

1. Mathematics teachers and instructors should adopt modern teaching pedagogies that are learner-centred and provides platform for the development of spatial skills in children and adult alike.
2. Government and other stakeholders should increase funding and support for mathematics teaching in terms of provision of computers and other teaching aids that guarantee optimal cognitive and spatial visualization abilities of secondary school mathematics students.
3. Educators, school administrators and non-governmental organizations should organize enlightenment campaigns and remedial classes for the female students to bridge the performance gap in spatial visualization and mathematical achievement.

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